

NEEM (*AZADIRACHTA INDICA* A. JUSS): ORGANISMS  
AFFECTED AND REFERENCE LIST UPDATE

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*Abstract.*—A compilation of neem literature for the last decade is presented that updates a review by Warthen 1979. The compilation includes literature citations and tables that list organisms affected by neem as well as activities and compounds.

*Key Words:* Neem, *Azadirachta indica*, *Melia azadirachta*, *M. indica*, Meliaceae, Margosa tree, Indian lilac

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In 1979, Warthen published a review of the neem literature that was entitled "*Azadirachta indica*: A Source of Insect Feeding Inhibitors and Growth Regulators." The review was very popular worldwide with scientists involved in neem research as well as with others who were either interested in neem or in the utilization of neem for insect pest control.

During the last decade, the number of neem publications has increased greatly. Since 1979, three international neem conferences have been held; proceedings (Schmutterer et al. 1980, Schmutterer and Ascher 1983, 1987) of these meetings and attendance have increased with each subsequent conference.

During this time period, Vikwood Ltd. formulated a neem seed extract (Margosan-O), for which EPA approval was granted for use on ornamental plants. Presently, W. R. Grace & Co. and Vikwood Ltd. are working cooperatively to market this product and to gain EPA approval for its utilization on edible plants as well.

Worldwide interest has been generated by neem as attested to in the 194 new citations in the last decade within this compilation.

The National Research Council, Office of International Affairs, recognizing this interest and the utilization potential for third world countries, called a meeting in April 1988 to consider the possibility of publishing a book on neem for the National Academy of Sciences.

Organisms affected by neem are listed in Table 1; the entries, addressed mainly to entomologists, are alphabetized by Phylum, Class, Order, Family, Genus, Species, and then Literature Citation. Activities, Compounds, and Literature Citations of neem, without reference to organisms affected, are listed in Table 2; entries are alphabetized by first author of the Literature Citation.

This compilation is not an exhaustive search of the literature for the last decade; many pre-1979 literature citations appear, and others (Warthen 1979, Schmutterer et al. 1980, Schmutterer 1981, Schmutterer and Ascher 1983, 1987, Olkowski 1987, and Jacobson 1988) should be consulted for further information and other references.

The compilation updates the review by Warthen (1979) and lists organisms in three Phyla, Molusca being new, that are affected by neem along with 277 (194 new) literature

Table 1. Organisms (family, genus, and species) affected by neem; activities, compounds, and literature citations.

Family	Genus and Species	Activity	Compound	Literature Citations
Phylum Arthropoda,	Class Acari:			
Tetranychidae	<i>Panonychus citri</i> (McGregor)			(Chiu 1982)
	Class Insecta	Order Coleoptera		
Bostrichidae	<i>Rhyzopertha dominica</i> (F.)	antifeedant		(Anonymous)
Bostrichidae	<i>Rhyzopertha dominica</i> (F.)	deterrent		(Devi and Mohandas 1982)
Bostrichidae	<i>Rhyzopertha dominica</i> (F.)	protectant		(Pereira and Wohlgemuth 1982)
Bostrichidae	<i>Rhyzopertha dominica</i> (F.)			(Qadri and Rao 1977)
Bruchidae	<i>Callosobruchius analis</i> (F.)	growth regulator	isonimolichinide	(Siddiqui et al. 1987)
Bruchidae	<i>Callosobruchius analis</i> (F.)	growth regulator	nimolichinoid acid	(Siddiqui et al. 1987)
Bruchidae	<i>Callosobruchius chinensis</i> (Lucas)	larval toxicant	plant oils	(Ali et al. 1984)
Bruchidae	<i>Callosobruchius maculatus</i> (F.)	antifeedant		(Anonymous)
Bruchidae	<i>Callosobruchius maculatus</i> (F.)	protectant	alkanes	(Ivbijaro 1983a)
Bruchidae	<i>Callosobruchius maculatus</i> (F.)	protectant		(Jotwani and Sircar 1967)
Bruchidae	<i>Callosobruchius maculatus</i> (F.)	protectant		(Pereira 1983)
Chrysomelidae	<i>Acalymma vittatum</i> (F.)	antifeedant		(Reed et al. 1981)
Chrysomelidae	<i>Acalymma vittatum</i> (F.)	feeding deterrent	azadirachtin	(Reed et al. 1982)
Chrysomelidae	<i>Acalymma vittatum</i> (F.)	feeding deterrent	salannin	(Reed et al. 1982)
Chrysomelidae	<i>Acalymma vittatum</i> (F.)	repellent	thionimone	(Chakravorty et al. 1969)
Chrysomelidae	<i>Aulacophora foveicollis</i> (Lucas)	repellent		(Pradhan et al. 1963)
Chrysomelidae	<i>Aulacophora foveicollis</i> (Lucas)	deterrent		(Pradhan and Jotwani 1968)
Chrysomelidae	<i>Aulacophora foveicollis</i> (Lucas)	antifeedant		(Pradhan and Jotwani 1971a)
Chrysomelidae	<i>Aulacophora foveicollis</i> (Lucas)	antifeedant		(Pradhan and Jotwani 1971b)
Chrysomelidae	<i>Diabrotica undecimpunctata howardi</i> Barber	antifeedant		(Reed et al. 1981)
Chrysomelidae	<i>Diabrotica undecimpunctata howardi</i> Barber	feeding deterrent	azadirachtin	(Reed et al. 1982)
Chrysomelidae	<i>Diabrotica undecimpunctata howardi</i> Barber	feeding deterrent	salannin	(Reed et al. 1982)
Chrysomelidae	<i>Galleria mellonella</i> (L.)	deterrent	azadirachtin	(Zanno et al. 1975)
Chrysomelidae	<i>Leptinotarsa decemlineata</i> (Say)	antifeedant		(Steets 1976)
Chrysomelidae	<i>Leptinotarsa decemlineata</i> (Say)	feeding inhibitor		(Zehnder and Warthen 1988)
Chrysomelidae	<i>Leptinotarsa decemlineata</i> (Say)	toxicant		(Zehnder and Warthen 1988)
Chrysomelidae	<i>Phyllotreta striolata</i> (F.)			(Meisner and Mitchell 1982)
Chrysomelidae	<i>Podagrica uniformis</i> (Jacoby)	repellent	azadirachtin	(Redknop 1979)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	hot tasting		(Ascher and Gsell 1981)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	deterrent	1,3-diacetylvilasinin	(Kraus et al. 1980)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	deterrent	3-desacetyl-salannin	(Kraus et al. 1980)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	deterrent	salannol	(Kraus et al. 1980)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	synergist	S421	(Lange and Schmutterer 1982)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	synergist	sesoxane	(Lange and Schmutterer 1982)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	synergist	tropical	(Lange and Schmutterer 1982)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	growth disruptant		(Rembold et al. 1980)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	growth regulator	azadirachtin	(Rembold et al. 1982)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	molt inhibitor	azadirachtin	(Schlüter 1984)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	growth disruptant	azadirachtin	(Schlüter 1985)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	antifeedant	azadirachtin	(Schmutterer and Rembold 1980)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	longevity	azadirachtin	(Steets 1975)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	reproduction	azadirachtin	(Steets and Schmutterer 1975)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	protectant	azadirachtin	(Steets and Schmutterer 1975)
Coccinellidae	<i>Epilachna varivestis</i> Mulsant	antifeedant		(Pereira and Wohlgemuth 1982)
Coccinellidae	<i>Cryptolestes ferrugineus</i> (Stephens)	antifeedant		(Anonymous)
Cucujidae	<i>Sitophilus oryzae</i> (L.)	toxicant	azadirachtin	(Iv-bijaro 1983b)
Curculionidae	<i>Sitophilus oryzae</i> (L.)	protectant		(Pereira and Wohlgemuth 1982)
Curculionidae	<i>Sitophilus oryzae</i> (L.)	antifeedant		(Anonymous)
Dermestidae	<i>Trogoderma granarium</i> Everts	attractant		(Chiu 1982)
Scarabaeidae	<i>Anomala cupripes</i> Hope	attractant		(Gupta 1973)
Scarabaeidae	<i>Holotrichia consanguinea</i> (Blanchard)	attractant		(Gupta 1973)
Scarabaeidae	<i>Holotrichia insularis</i> Brenske	attractant		(Sachan and Pal 1974)
Scarabaeidae	<i>Holotrichia insularis</i> Brenske	attractant		(Gupta 1973)
Scarabaeidae	<i>Holotrichia serrata</i> F.	deterrent		(Ladd et al. 1978)
Scarabaeidae	<i>Popillia japonica</i> Newman	growth inhibitor		(Ladd et al. 1978)
Scarabaeidae	<i>Popillia japonica</i> Newman	deterrent		(Ladd et al. 1978)
Scarabaeidae	<i>Popillia japonica</i> Newman	growth	azadirachtin	(Ladd et al. 1984)
Scarabaeidae	<i>Popillia japonica</i> Newman	growth regulator	azadirachtin	(Ladd et al. 1984)
Tenebrionidae	<i>Tenebrio molitor</i> L.	growth regulator	azadirachtin	(Parke 1982)
Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)	antifeedant		(Redfern et al. 1984a)
Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)	repellent		(Anonymous)
Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)	repellent	Margosan-O	(Jilani and Su 1984)
Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)	growth inhibitor	Margosan-O	(Jilani et al. 1988)
Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)			(Jilani et al. 1988)
Agromyzidae	<i>Liriomyza sativae</i> Blanchard	Order Diptera		
Agromyzidae	<i>Liriomyza sativae</i> Blanchard	systemic		(Larew et al. 1984)
				(Webb et al. 1983)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Agromyzidae	<i>Liriomyza sativae</i> Blanchard	systemic	azadirachtin	(Webb et al. 1984)
Agromyzidae	<i>Liriomyza trifolii</i> (Burgess)	biocontrol		(Fagoonee and Toory 1983)
Agromyzidae	<i>Linomyza trifolii</i> (Burgess)	insecticide	Margosan-O	(Knodel-Montz et al. 1985)
Agromyzidae	<i>Liriomyza trifolii</i> (Burgess)	systemic		(Larew et al. 1984)
Agromyzidae	<i>Linomyza trifolii</i> (Burgess)	repellent		(Larew et al. 1985a)
Agromyzidae	<i>Linomyza trifolii</i> (Burgess)	insecticide		(Larew et al. 1985b)
Agromyzidae	<i>Linomyza trifolii</i> (Burgess)	toxicant		(Larew et al. 1985c)
Agromyzidae	<i>Liriomyza trifolii</i> (Burgess)	systemic	azadirachtin	(Webb et al. 1983)
Agromyzidae	<i>Liriomyza trifolii</i> (Burgess)	antifeedant	azadirachtin	(Webb et al. 1984)
Calliphoridae	<i>Lucilia cuprina</i> (Wiedemann)	ovipositional	azadirachtin	(Rice et al. 1985)
Calliphoridae	<i>Lucilia cuprina</i> (Wiedemann)	repellent		(Rice et al. 1985)
Cecidomyiidae	<i>Orseolia oryzae</i> (Wood-Mason)	deterrent		(Chiu et al. 1985)
Cecidomyiidae	<i>Orseolia oryzae</i> (Wood-Mason)	deterrent		(Chiu et al. 1985)
Culicidae	<i>Aedes aegypti</i> (L.)	insecticide	azadirachtin	(Zebitz 1984)
Culicidae	<i>Aedes aegypti</i> (L.)		azadirachtin	(Zebitz 1986)
Culicidae	<i>Aedes togoi</i> (Theobald)		azadirachtin	(Zebitz 1986)
Culicidae	<i>Anopheles stephensi</i> Liston		azadirachtin	(Zebitz 1986)
Culicidae	<i>Culex quinquefasciatus</i> Say		azadirachtin	(Zebitz 1986)
Muscidae	<i>Musca autumnalis</i> De Geer	molting inhibitor	azadirachtin	(Zebitz 1986)
Muscidae	<i>Musca domestica</i> L.		azadirachtin	(Gaaboub and Hayes 1984)
Muscidae	<i>Musca domestica</i> L.	feeding deterrent	salannin	(Qadri and Rao 1977)
Tephritidae	<i>Cevattis capitata</i> (Wiedemann)			(Warthen et al. 1978b)
				(Steffens and Schmutterer 1982)
		Order Heteroptera		
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	nutrition	azadirachtin	(Karnavar 1987)
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	reproduction	azadirachtin	(Karnavar 1987)
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	molting inhibitor	azadirachtin	(Redfern et al. 1979)
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	antifeedant	azadirachtin	(Redfern et al. 1980)
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	growth disruptor	azadirachtin	(Redfern et al. 1980)
Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas)	growth	azadirachtin	(Redfern et al. 1984a)
Miridae	<i>Piesma quadratum</i> (Fieber)			(Steets 1975)
Pyrrhocoridae	<i>Dysdercus cingulatus</i> F.	antifeedant		(Abraham and Ambika 1979)
Pyrrhocoridae	<i>Dysdercus cingulatus</i> F.	deterrent		(Abraham and Ambika 1979)
Pyrrhocoridae	<i>Dysdercus cingulatus</i> F.	insecticidal		(Abraham and Ambika 1979)
Pyrrhocoridae	<i>Dysdercus fasciatus</i> Sign.	deterrent		(Ruscoe 1972)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Pyrrhocoridae	<i>Dysdercus fasciatus</i> Sign.	growth disruptor		(Ruscoe 1972)
Pyrrhocoridae	<i>Dysdercus fasciatus</i> Sign.	repellent		(Ruscoe 1972)
Pyrrhocoridae	<i>Dysdercus koenigii</i> (F.)		azadirachtin	(Koul 1984a)
Pyrrhocoridae	<i>Dysdercus koenigii</i> (F.)	antifeedant	azadirachtin	(Koul 1984b)
Reduviidae	<i>Rhodnius prolixus</i> Stål	antifeedant	azadirachtin	(Garcia and Rembold 1984)
Reduviidae	<i>Rhodnius prolixus</i> Stål	molting inhibitor	7-acetyl-azadirachtin(a)	(Garcia et al. 1984)
Reduviidae	<i>Rhodnius prolixus</i> Stål	antifeedant	azadirachtin	(Garcia et al. 1984)
	Order Homoptera			
Aleyrodidae	<i>Bemisia tabaci</i> (Gennadius)	deterrent		(Coudriet et al. 1985)
Aleyrodidae	<i>Bemisia tabaci</i> (Gennadius)	toxicant		(Coudriet et al. 1985)
Aphididae	<i>Myzus persicae</i> (Sulzer)	repellent		(Griffiths et al. 1978)
Aphididae	<i>Rhopalosiphum nymphalacae</i> (L.)	deterrent		(Goyal et al. 1971)
Cicadellidae	<i>Nephotettix virescens</i> (Distant)	growth disruptor		(Heyde et al. 1985)
Cicadellidae	<i>Nephotettix virescens</i> (Distant)	virus transmission		(Mariappan et al. 1982)
Delphacidae	<i>Nilaparvata lugens</i> (Stål)	reduced survival		(Saxena and Khan 1985)
Delphacidae	<i>Nilaparvata lugens</i> (Stål)			(Chiu 1982)
Delphacidae	<i>Nilaparvata lugens</i> (Stål)		azadirachtin	(Saxena et al. 1984)
Delphacidae	<i>Nilaparvata lugens</i> (Stål)			(Shin'foom 1985)
Apidae	<i>Apis mellifera</i> L.	antifeedant		(Rembold et al. 1980)
Apidae	<i>Apis mellifera</i> L.	antifeedant	azadirachtin	(Rembold and Czoppelt 1981)
Apidae	<i>Apis mellifera</i> L.	growth regulator	azadirachtin	(Rembold and Czoppelt 1981)
Apidae	<i>Apis mellifera</i> L.	growth regulator	azadirachtin	(Rembold et al. 1982)
Apidae	<i>Apis mellifera</i> L.			(Sharma et al. 1980)
Tenthredinidae	<i>Femusa pusilla</i> (Lepelletier)	insecticide		(Larew et al. 1987)
	Order Lepidoptera			
Arctiidae	<i>Amsacta moorei</i> Butler	deterrent		(Patel et al. 1968)
Gelechiidae	<i>Pectinophora gossypiella</i> (Saunders)	biosynthesis	azadirachtin	(Kubo and Klocke 1982)
Gelechiidae	<i>Sitotroga cerealella</i> (Olivier)	antifeedant		(Anonymous)
Gelechiidae	<i>Sitotroga cerealella</i> (Olivier)	antifeedant	brestan	(Asari and Dale 1977)
Gelechiidae	<i>Sitotroga cerealella</i> (Olivier)	antifeedant		(Devi and Mohandas 1982)
Gelechiidae	<i>Sitotroga cerealella</i> (Olivier)	protectant		(Pereira and Wohlgemuth 1982)
Geometridae	<i>Ascotis selenaria</i> (Denis and Schiffermüller)	residual effect		(Meisner et al. 1976)
Gracillariidae	<i>Phyllocnistis citrella</i> Stainton			(Chiu 1982)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Lymantriidae	<i>Euproctis lunata</i> Walker	deterrent		(Babu and Beri 1969)
Lymantriidae	<i>Euproctis lunata</i> Walker	repellent		(Pradhan et al. 1963)
Lymantriidae	<i>Euproctis lunata</i> Walker	deterrent		(Pradhan and Jotwani 1968)
Lymantriidae	<i>Euproctis lunata</i> Walker			(Pradhan and Jotwani 1971a)
Lymantriidae	<i>Euproctis lunata</i> Walker			(Pradhan and Jotwani 1971b)
Lymantriidae	<i>Lynmantria dispar</i> (L.)			(Skatulla and Meisner 1975)
Noctuidae	<i>Achaea janata</i> (L.)	insect control		(Chiu 1982)
Noctuidae	<i>Ariathisa (Spodoptera) abyssina</i> (Guenée)	oviposition		(Pathak and Krishna 1986)
Noctuidae	<i>Earias vitella</i> (Sabricius)	egg hatchability		(Pathak and Krishna 1986)
Noctuidae	<i>Earias vitella</i> (Sabricius)	feeding deterrent	azadirachtin	(Meisner et al. 1981)
Noctuidae	<i>Earias insulana</i> (Boisduval)	feeding deterrent	salannin	(Meisner et al. 1981)
Noctuidae	<i>Earias insulana</i> (Boisduval)	feeding deterrent	azadirachtin	(Kubo and Klocke 1982)
Noctuidae	<i>Heliothis virescens</i> (F.)	biosynthesis		(Lee et al. 1985)
Noctuidae	<i>Heliothis virescens</i> (F.)	insecticide		(Ruscoe 1972)
Noctuidae	<i>Heliothis virescens</i> (F.)	deterrent		(Ruscoe 1972)
Noctuidae	<i>Heliothis virescens</i> (F.)	growth disruptor		(Ruscoe 1972)
Noctuidae	<i>Heliothis virescens</i> (F.)	repellent		(Zanno et al. 1975)
Noctuidae	<i>Heliothis virescens</i> (F.)	deterrent		(Kubo and Klocke 1982)
Noctuidae	<i>Heliothis zea</i> (Boddie)	ecdysis inhibitor	azadirachtin	(Kubo and Klocke 1982)
Noctuidae	<i>Heliothis zea</i> (Boddie)	biosynthesis	azadirachtin	(Chiu 1982)
Noctuidae	<i>Leucania venalba</i> Moore			(Chiu 1982)
Noctuidae	<i>Mamestra brassicae</i> (L.)	spermiogenetic	azadirachtin	(Shimizu 1988)
Noctuidae	<i>Mamestra brassicae</i> (L.)	spermiogenetic	Margosan-O	(Shimizu 1988)
Noctuidae	<i>Pseudaletia separata</i> (Walker)	morphogenetic		(Schmutterer et al. 1983)
Noctuidae	<i>Sesamia calamistis</i> Hampson	antifeedant		(Ho 1983)
Noctuidae	<i>Spodoptera eridania</i> (Cramer)	antifeedant	limonoids	(Lidert et al. 1985)
Noctuidae	<i>Spodoptera eridania</i> (Cramer)	antifeedant	azadirachtin	(Lidert et al. 1985)
Noctuidae	<i>Spodoptera exigua</i> (Hübner)	toxicant	avermectin	(Moar and Trumble 1987)
Noctuidae	<i>Spodoptera exigua</i> (Hübner)	toxicant	<i>Bacillus thuringiensis</i>	(Moar and Trumble 1987)
Noctuidae	<i>Spodoptera exigua</i> (Hübner)			(Prabhaker et al. 1986)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	biosynthesis	azadirachtin	(Kubo and Klocke 1982)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	insecticide		(Lee et al. 1985)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	feeding deterrent		(Rafa 1987)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	antifeedant	azadirachtin	(Redfern et al. 1980)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	growth disruptor	azadirachtin	(Redfern et al. 1980)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	antifeedant		(Redfern et al. 1984b)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	antifeedant		(Stokes et al. 1983a)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	antifeedant		(Stokes et al. 1983b)
Noctuidae	<i>Spodoptera frugiperda</i> (J. E. Smith)	antifeedant	azadirachtin	(Warthen et al. 1978a)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)	antifeedant		(El-Sayed 1985)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)	repellent		(El-Sayed 1985)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)	feeding deterrent	azadirachtin	(Meisner et al. 1981)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)	antifeedant	salannin	(Meisner et al. 1981)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)	growth regulator		(Meisner and Ascher 1983)
Noctuidae	<i>Spodoptera littoralis</i> (Boisduval)		punic acid	(Meisner et al. 1983)
Noctuidae	<i>Spodoptera litura</i> (F.)			(Chiu 1982)
Noctuidae	<i>Spodoptera litura</i> (F.)	juvenile hormone		(Gujar and Mehrotra 1983)
Noctuidae	<i>Spodoptera litura</i> (F.)	antifeedant	azadirachtin	(Joshi and Ramaprasad 1975)
Noctuidae	<i>Spodoptera litura</i> (F.)	deterrent		(Joshi et al. 1978)
Noctuidae	<i>Spodoptera litura</i> (F.)	repellent		(Pradhan et al. 1963)
Noctuidae	<i>Spodoptera litura</i> (F.)	deterrent		(Pradhan and Jotwani 1968)
Noctuidae	<i>Spodoptera litura</i> (F.)			(Pradhan and Jotwani 1971a)
Noctuidae	<i>Spodoptera litura</i> (F.)			(Pradhan and Jotwani 1971b)
Noctuidae	<i>Spodoptera litura</i> (F.)	growth regulator		(Prabhakar et al. 1986)
Papilionidae	<i>Trichoplusia ni</i> (Hübner)	repellent	azadirachtin	(Redknop 1979)
Pieridae	<i>Papilio demoleus</i> (L.)	deterrent		(Ruscoe 1972)
Pieridae	<i>Pieris brassicae</i> (L.)	growth disruptor		(Ruscoe 1972)
Pieridae	<i>Pieris brassicae</i> (L.)	repellent		(Ruscoe 1972)
Pieridae	<i>Pieris brassicae</i> (L.)	deterrent		(Zanno et al. 1975)
Pieridae	<i>Pieris rapae</i> (L.)			(Chiu 1982)
Pyralidae	<i>Antigastra catalaunalis</i> Duponchel	deterrent		(Chadha 1977)
Pyralidae	<i>Cnaphalocrocis medinalis</i> (Guenée)	morphogenetic		(Schmutterer et al. 1983)
Pyralidae	<i>Crocidolomia binotalis</i> Zeller			(Fagoonée and Lange 1981)
Pyralidae	<i>Ephesia cautella</i> (Walker)	protectant		(Pereira and Wohlgemuth 1982)
Pyralidae	<i>Ephesia kuehniella</i> Zeller	growth disruptor		(Rembold et al. 1980)
Pyralidae	<i>Ephesia kuehniella</i> Zeller	growth regulator	azadirachtin	(Rembold et al. 1982)
Pyralidae	<i>Ephesia kuehniella</i> Zeller			(Sharma et al. 1980)
Pyralidae	<i>Maliarpha separatella</i> Ragonot	antifeedant		(Ho 1983)
Pyralidae	<i>Ostrinia farnacalis</i> Guenée	growth disruptor	azadirachtin	(Shinfoon et al. 1985)
Pyralidae	<i>Ostrinia nubilalis</i> (Hübner)	antifeedant	azadirachtin	(Arnason et al. 1985)
Pyralidae	<i>Ostrinia nubilalis</i> (Hübner)	insecticide	azadirachtin	(Arnason et al. 1985)

Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Sphingidae	<i>Manduca sexta</i> (L.)	ecdysteroid titre	azadirachtin	(Pener et al. 1988)
Sphingidae	<i>Manduca sexta</i> (L.)	growth regulator	azadirachtin	(Schlüter et al. 1985)
Yponomeutidae	<i>Plutella maculipennis</i> Curtis	synergist	piperonyl butoxide	(Steets 1975)
Yponomeutidae	<i>Plutella xylostella</i> (L.)	deterrent		(Adhikary 1985)
Yponomeutidae	<i>Plutella xylostella</i> (L.)	growth disruptor		(Lange and Schmutterer 1982)
Yponomeutidae	<i>Plutella xylostella</i> (L.)	repellent		(Ruscoe 1972)
Yponomeutidae	<i>Plutella xylostella</i> (L.)	antifeedant		(Ruscoe 1972)
Yponomeutidae	<i>Plutella xylostella</i> (L.)	antifeedant		(Tan and Sudderuddin 1978)
		Order Orthoptera		
Acrididae	cockroaches	toxicant		(Anonymous 1986)
Acrididae	<i>Locusta</i>	nutrition	azadirachtin	(Karnavar 1987)
Acrididae	<i>Locusta</i>	reproduction	azadirachtin	(Karnavar 1987)
Acrididae	<i>Locusta migratoria</i> (L.)	deterrent		(Pradhan and Jotwani 1968)
Acrididae	<i>Locusta migratoria</i> (L.)			(Pradhan and Jotwani 1971a)
Acrididae	<i>Locusta migratoria</i> (L.)			(Pradhan and Jotwani 1971b)
Acrididae	<i>Locusta migratoria</i> (L.)	molt inhibitor	azadirachtin	(Rembold et al. 1983)
Acrididae	<i>Locusta migratoria</i> (L.)	growth regulator	azadirachtin	(Rembold et al. 1983)
Acrididae	<i>Locusta migratoria</i> (L.)	sexual behavior	azadirachtin	(Shalom and Pener 1984)
Acrididae	<i>Locusta migratoria</i> (L.)	juvenile hormone	azadirachtin	(Shalom and Pener 1984)
Acrididae	<i>Locusta migratoria</i> (L.)	pest control		(Sinha and Gulati 1963)
Acrididae	<i>Locusta migratoria</i> (L.)	deterrent		(Attri 1977)
Acrididae	<i>Schistocerca gregaria</i> Forskål	deterrent	azadirachtin	(Butterworth and Morgan 1968)
Acrididae	<i>Schistocerca gregaria</i> Forskål	deterrent	azadirachtin	(Butterworth and Morgan 1971)
Acrididae	<i>Schistocerca gregaria</i> Forskål	deterrent	azadirachtin	(Gill and Lewis 1971)
Acrididae	<i>Schistocerca gregaria</i> Forskål	systemic	azadirachtin	(Gill and Lewis 1971)
Acrididae	<i>Schistocerca gregaria</i> Forskål	deterrent		(Goyal et al. 1971)
Acrididae	<i>Schistocerca gregaria</i> Forskål	antifeedant	meliantriol	(Lavie et al. 1967)
Acrididae	<i>Schistocerca gregaria</i> Forskål	repellent		(Pradhan et al. 1963)
Acrididae	<i>Schistocerca gregaria</i> Forskål	deterrent		(Pradhan and Jotwani 1968)
Acrididae	<i>Schistocerca gregaria</i> Forskål			(Pradhan and Jotwani 1971a)
Acrididae	<i>Schistocerca gregaria</i> Forskål			(Pradhan and Jotwani 1971b)
Acrididae	<i>Schistocerca gregaria</i> Forskål	egg hatchability		(Singh and Singh 1987)
Acrididae	<i>Schistocerca gregaria</i> Forskål	pest control		(Sinha and Gulati 1963)
Blattidae	<i>Periplaneta americana</i> (L.)	plant pesticides	azadirachtin	(Qadri and Ahmed 1979)



Table 1. Continued.

Family	Genus and Species	Activity	Compound	Literature Citations
Blattidae	<i>Periplaneta americana</i> (L.)	molting effect	azadirachtin	(Qadri and Narsaiah 1978)
Gryllidae	<i>Acheta domestica</i> (L.)	antifeedant	azadirachtin	(Warthen and Uebel 1980)
Gryllidae	<i>Acheta domestica</i> (L.)	molting disruptor	azadirachtin	(Warthen and Uebel 1980)
Pyrgomorphidae	<i>Poecilocus pictus</i> F.	deterrent		(Pradhan and Jotwani 1968)
Pyrgomorphidae	<i>Poecilocus pictus</i> F.			(Pradhan and Jotwani 1971a)
Pyrgomorphidae	<i>Poecilocus pictus</i> F.	repellent		(Pradhan and Jotwani 1971b)
Phylum Mollusca,	Class Gastropoda:	Order Stylommatophora		
Prosobranchia	<i>Melania scabra</i>	snail control		(Muley 1978)
Phylum Nematoda:				
	<i>Pratylenchus brachyurus</i> <sup>1</sup>	maize yield control		(Egunjobi and Afolami 1976)
	<i>Rotylenchulus reniformis</i> <sup>2</sup>			(Verma and Prasad 1970)
Miscellaneous	albino rats	toxicant		(Qadri et al. 1984)
	arthropods	antifeedant		(Freeman and Andow 1983)
	cotton boll worms	insecticide		(Thangavel et al. 1975)
	crop pests			(Anonymous 1979a)
	fowl-pox virus	antiviral		(Rai and Sethi 1972)
	fungi nematodes			(Khan et al. 1974)
	gregarious locust hoppers	unpalatable		(Batra 1980)
	leaf miners	toxicant	alkanes	(Anonymous 1986)
	mosquitoes	insecticidal	alkanes	(Chavan 1983)
	mosquitoes	larvicidal	azadirachtin	(Chavan 1983)
	North American grasshoppers			(Mulkern 1971)
	potato virus X	antiviral		(Singh 1971)
	shield bug			(Leuschner 1972)
	stored product insects			(Girish and Jain 1974)
	stored product insects	repellent		(Jilani and Malik 1973)
	stored product insects	insecticide		(Jotwani and Srivastava 1981)
	stored product insects	repellent		(Qadri 1973)
	vaccinia virus	antiviral		(Rai and Sethi 1972)
	wheat pests			(Jotwani and Sircar 1965)

<sup>1</sup> (Godfrey, 1929) Filipjev & Schuurmans Stekhoven, 1941.

<sup>2</sup> Linford & Oliveira, 1940.

Table 2. Activities, compounds, and literature citations of neem without reference to insects.

Activity	Compound	Literature Citation	
pyrethrin stabilizer	neem	(Ahmed et al. 1976)	
miscella refining	neem oil	(Ahuja et al. 1976)	
		(Anonymous 1977)	
		(Anonymous 1979b)	
		(Anonymous 1980)	
	azadirachtin	(Anonymous 1981)	
		(Anonymous 1982a)	
	limonoids	(Anonymous 1982b)	
	azadirachtin	(Anonymous 1982b)	
	azadirachtin	(Anonymous 1985a)	
		(Anonymous 1985b)	
deterrent		(Arigrabu and Don-Pedro 1971)	
pharmaceutical		(Aschenbach 1982)	
	kaempferol	(Basak and Chakraborty 1968)	
	nimbin	(Basak and Chakraborty 1968)	
	quercetin	(Basak and Chakraborty 1968)	
	$\beta$ -sitosterol	(Basak and Chakraborty 1968)	
	azadirachtin	(Bilton et al. 1985)	
	azadirachtin	(Bilton et al. 1987)	
	antifeedant	azadirachtin	(Broughton et al. 1985)
	antifeedant	azadirachtin	(Broughton et al. 1985)
		tetranortriterpenoid	(Bruhn et al. 1984)
feeding inhibitor	azadirachtin	(Butterworth et al. 1972)	
	azadirachtin	(Chadha 1986)	
		(Chiu 1983)	
		(Connolly et al. 1968)	
		(Doria 1981)	
	repellent	azadirachtin	(Duke 1983)
		nimbolide	(Ekong 1967)
		gedunin	(Ekong et al. 1969)
		nimbin b	(Ekong et al. 1969)
		nimbin a	(Ekong et al. 1969)
biosynthesis	nimbolide	(Ekong et al. 1971)	
	crop protection	(Fagoonee 1979)	
		azadirachtin	(Forster 1983)
		meliacin	(Garg and Bhakuni 1984a)
		tetranortriterpenoid	(Garg and Bhakuni 1984a)
		salannolide	(Garg and Bhakuni 1984b)
		tetranortriterpenoid	(Garg and Bhakuni 1984b)
		nimbraflavone	(Garg and Bhakuni 1984c)
	feeding inhibitor		(Gilbert 1982)
		nimbin	(Harris et al. 1968)
leaf development		(Harzal 1977)	
	antifeedant	azadirachtin	(Helson 1984)
		nimbin	(Henderson et al. 1963)
		salannin	(Henderson et al. 1964)
		salannin	(Henderson et al. 1968)
			(Hoddy 1985)
			(Jacobson 1980)
			(Jacobson et al. 1983)
	natural resistance		(Jacobson 1986)
			(Jain 1983)

Table 2. Continued.

Activity	Compound	Literature Citation
general uses		(Ketkar 1976)
		(Ketkar 1979)
	17- $\beta$ -hydroxyazadiradion	(Kraus and Cramer 1978)
	epi-azadiradion	(Kraus and Cramer 1978)
antifeedant	1,3-diacetylvilasinin	(Kraus and Cramer 1981)
antifeedant	3-deacetylsalannin	(Kraus and Cramer 1981)
antifeedant	salannol	(Kraus and Cramer 1981)
	tetranortriterpenoids	(Kraus et al. 1981)
antifeedant	meliacin	(Kraus 1983)
	azadirachtin	(Kraus et al. 1985)
	azadirachtin	(Kraus 1986)
	azadirachtin	(Kubo 1979)
control agent	azadirachtin	(Kubo and Klocke 1981)
antifeedant	deacetylazadirachtinol	(Kubo et al. 1984)
	piperonyl butoxide	(Lange and Feuerhake 1984)
insecticide		(Larew 1985)
systemic	neem toxin	(Larew 1988)
	tetranortriterpenoids	(Lavie and Jain 1967)
	azadiradione	(Lavie et al. 1971)
	azadirone	(Lavie et al. 1971)
	epoxyazadiradione	(Lavie et al. 1971)
	gedunin	(Lavie et al. 1971)
	tetranortriterpenoids	(Madhusudanan et al. 1984)
antifeedant	azadirachtin	(Malik and Naqvi 1984)
repellent	azadirachtin	(Malik and Naqvi 1984)
repellent	azadirachtin	(Mansour and Ascher 1983)
	chemicals	(Mitra et al. 1947)
	nimbin	(Mitra 1957)
	constituents	(Mitra 1963)
	nimbidic acid	(Mitra et al. 1970)
	nimbidinin	(Mitra et al. 1970)
	nimbidic acid	(Mitra et al. 1971)
	nimbidinin	(Mitra et al. 1971)
feeding inhibitor	azadirachtin	(Morgan and Thornton 1973)
antifeedant	azadirachtin	(Nakanishi 1975)
	nimbin	(Narasimhan 1959)
	nimbin	(Narayanan et al. 1962)
	nimbin	(Narayanan et al. 1964a)
	nimbin	(Narayanan et al. 1964b)
	nimbin	(Narayanan et al. 1964c)
	nimbin	(Narayanan and Pachapurkar 1965)
	nimbinic acid	(Narayanan and Pachapurkar 1966)
	nimbinin	(Narayanan et al. 1967)
	vepinin	(Narayanan et al. 1969)
	polysaccharide	(Nayak et al. 1978)
		(Olkowski 1978)
	vilasinin	(Pachapurkar and Kornule 1974)
general uses		(Parmar 1984a)
general uses		(Parmar 1984b)
general uses		(Parmar 1985a)

Table 2. Continued.

Activity	Compound	Literature Citation
nitrogen fixing		(Parmar 1985b) (Parmar 1985c) (Parmar 1985d)
antifeedant	chemical constituents	(Peterson 1983)
antinuclear study	azadirachtin	(Pickett 1985)
deterrent	nimbidin	(Pillai and Santhakumari 1984) (Pradhan et al. 1962) (Quasim and Dutia 1970) (Radwanski 1977a) (Radwanski 1977b) (Radwanski 1977c) (Radwanski 1977d) (Radwanski and Wickens 1981)
general uses		(Raman and Santhanagopalan 1978)
general uses	tiglic acid	(Rembold 1984)
growth regulator	azadirachtin	(Sankaran et al. 1984)
antifeedant	vapaol	(Schroeder and Nakanishi 1987)
repellent	azadirachtin	(Schwinger 1982)
repellent	warburganal	(Schwinger 1982)
spermicide	sodium nimbidinate	(Sharma and Saksena 1959)
	bitter principle	(Siddiqui 1942)
	nimbidin series	(Siddiqui and Mitra 1945) (Siddiqui et al. 1975a) (Siddiqui et al. 1975b) (Siddiqui et al. 1978) (Siddiqui et al. 1984) (Siddiqui et al. 1984) (Siddiqui et al. 1986) (Siddiqui et al. 1988)
	azadiradione	(Siddiqui et al. 1978)
	17-hydroxyazadiradion	(Siddiqui et al. 1984)
	nimocinol	(Siddiqui et al. 1984)
	tetranortriterpenoid	(Siddiqui et al. 1986) (Siddiqui et al. 1988)
mode of action	azadirachtin	(Sieber 1985)
general uses		(Sinha and Gulati 1969)
contraceptive		(Sinha et al. 1984)
poisoning		(Sinniah and Baskaran 1981)
sunlight effect	fatty acids	(Skellon et al. 1962)
	azadirachtin	(Stokes and Redfern 1982)
	kaempterol-3-glucoside	(Subramanian and Nair 1972)
	myricetin-3-l-arabinoside	(Subramanian and Nair 1972)
	quercetin-3-galactoside	(Subramanian and Nair 1972)
cardiovascular		(Thompson and Anderson 1978)
	chemical constituents	(Tirimanna 1983)
	azadirachtin	(Uebel et al. 1979)
pests of neem		(Uthamasamy et al. 1973)
antifeedant	nimbidin	(Verma 1974)
antifeedant	nimbin	(Verma 1974) (Warthen 1979)
	azadirachtin	(Warthen et al. 1984)
nitrogen fixing		(Watanabe et al. 1981)
	azadirachtin	(Yamasaki et al. 1986)
phagorepellent	azadirachtin	(Zanno 1974)
growth disruptor	azadirachtin	(Zanno 1974)
systemic	azadirachtin	(Zanno 1974)
	nimbin	(Ziffler et al. 1966)

citations; the review by Warthen (1979) contained 105 citations. Within the Phylum Arthropoda, 7 Orders are represented in Class Insecta with Hymenoptera being a new order affected by neem. Since the review by Warthen (1979), additional species affected by neem have been added to the literature: 11 in Coleoptera, 9 in Diptera, 4 in Heteroptera, 3 in Homoptera, 22 in Lepidoptera, and 2 in Orthoptera.

Although literature is extensive and progress in research has been accomplished, the commercial development of a marketable natural insect pest control agent has been painstakingly slow. However, the novel chemistry within these literature citations pertaining to neem has been a stimulus to chemists to synthesize active analogs that might have the possibility for commercial development as insect feeding deterrents or growth regulators.

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